METHOD OF TEST DETERMINING PAVEMENT PROFILES WITH THE 25-FOOT (7.6-METER) PROFILOGRAPH

SCOPE

This IM describes procedures used to test pavements and bridge decks for smoothness with the California-Type, 25-foot (7.6-Meter) Profilograph, to determine the Profile Index from the profilograms, and to locate individual bumps and dips for removal according to Standard Specifications.

The 25-foot (7.6-meter) Profilograph is a rolling straight edge. That is, it measures vertical deviations from a moving 25-foot (7.6-meter) reference plane. The pavement profile is graphically recorded on a profilogram on a scale of one millimeter equal to three-tenths meter (one inch is equal to twenty-five feet) longitudinally and one millimeter equal to one millimeter (one inch equal to one inch), or full scale, vertically. The Profile Index is determined from the profilogram by measuring and summing "scallops" that appear outside of a "blanking band" and is reported in millimeters/kilometer (inches/mile). Individual bumps are located by use of a special bump template.

PROCEDURE

A. Apparatus

1. California- or Ames Engineering-Type, 25-Foot (7.6-Meter) Profilograph, or approved alternatives

2. Blanking band, which is a plastic scale 1.70 in. (43.2 mm) wide and 21.12 in. (536.4 mm) long representing a pavement length of 528 ft. (160.9 m) at a scale of 1 in. = 25 ft. (1 mm = 0.3 m). Near the center of the scale is an opaque band 0.2 in. (5.1 mm) wide extending the entire length of 21.12 in. (536.4 mm). On either side of this band are scribed lines 0.1 in. (2.5 mm) apart, parallel to the opaque band. These lines serve as a convenient scale to measure deviations or excursions of the graph above or below the blanking band, which are called "scallops."

3. Scale graduated in tenths of an inch (millimeters)

4. Medium-point ballpoint pen in red ink or other contrasting color to the profile trace

5. Calculator

6. Plain recording chart paper (Honeywell 5701) for the manual units

7. Bump template, which is a plastic template having a line 1 in. (25.4 mm)-long scribed on one face with a small hole or scribed mark at either end, and a slot (or edge) a distance equal to the maximum bump specified, from and parallel to the scribed line [usually 0.5 in. (12.7 mm), but may be 0.3 in. (7.6 mm)]. See Figure 12. The 1 in. (25.4 mm) line corresponds to a longitudinal distance of 25 ft. (7.6 m) on the longitudinal scale of the profilogram.

8. Reporting Form #821301

B. Personnel, Transportation and Assembly

1. Two people are required to assemble and operate the profilograph. Additional people may be necessary to provide signing and flagging protection.

2. The Profilograph consists of a lightweight aluminum truss, which easily divides into three segments by the use of four quick-acting clamps. These three segments will fit into a full-size pickup and require about ten minute's assembly time. Sections are match-marked to assure correct assembly. The recorder is mounted on top of the center section and is connected to the bicycle wheel through a chain drive and gearbox assembly for longitudinal movement, and a control cable for vertical movement.

3. The recorder box should always be transported in the pickup cab to protect it from weather and kept covered for dust protection when not in use.

4. Blanking bands will warp from heat and scratch easily. Either leave them in the office or cover with cloth and keep out of sunlight when transporting.

C. Traffic Control

1. Follow Traffic Control Layouts 520-51B and 521-51 when performing Profilograph testing on pavements or bridges under traffic.

2. Remember that these are minimal traffic control layouts and that additional signing or more elaborate traffic control layouts (such as a complete lane closure by maintenance forces) may be required. Two-way radios may also be required.

3. Safety first! No test result is worth an accident, personal injury or fatality.

D. Calibration

1. Each District and contractor owning a Profilograph should establish a 500 ft. to 1000 ft. (150 m to 300 m) distance calibration test section. This test section should be lightly traveled, relatively flat, and used monthly or more frequently when you suspect you have a problem. The Special Investigations Section of the Central Materials Laboratory uses a rotating calibration wheel.

2. The Special Investigations Section of the Central Laboratory should be contacted to correct any Iowa DOT equipment malfunctions.

3. All District and contractor-owned Profilographs must be calibrated annually on a 500-ft. (150 m) test section maintained by the Central Materials Laboratory. This involves repair and maintenance of Iowa DOT machines, longitudinal distance calibration on the 500 ft. (150 m) test section, and comparison of all Profilographs to produce identical profilograms on the 500 ft. (150 m) test section when viewed on a light box. A rotating calibration wheel may also be used. The entire Profilographs must be assembled for inspection of condition. Contractor-owned ProScan units must also be calibrated annually in the Central Materials Laboratory.

4. Longitudinal calibration consists of pushing the Profilograph over a pre-measured test distance 500 to 1000 ft. (150 m to 300 m) and determining the chart scale factor by dividing the pre-measured test distance in meters by the length of chart paper in millimeters (inches). This factor should be 0.30 (1mm = 0.30 m) [25 (1 in. = 25 ft.)]. If not, the chart drive mechanism should be adjusted until the chart scale factor is 0.30 (25), ± 0.2%. A rotating calibration wheel may also be used with the same calibration test tolerance.

5. For vertical calibration, the Profilograph should be stationary. Using pre-measured calibration blocks [measured to the nearest 0.01 in. (.30 mm)], pull or slide the block(s) under the recording wheel. Measure the vertical trace line from the base line to the peak and return. (**NOTE:** The trace line must return to the base line.) Tolerance will be ± 0.0 in. (± 0.0 mm). A rotating calibration wheel may also be used with the same calibration test tolerance.

6. Note the filter number when the computer Profilograph is calibrated. The Special Investigations Engineer will send out one sheet.

PROFILOGRAPH CALIBRATION FACTORS

			FILTER SETTINGS		TIRE PRESSURE	
MANUFACTURER	MANUAL	COMPUTER	DATA	NULL	170kPa (25 PSI)	OTHER
AMES	X	---	---	---	---	VARIABLE
AMES	---	X	2.0	---	X	---
COX	X	---	---	---	X	---
COX ≥ VER. 2.11	---	X	2.0	---	X	---
COX < VER. 2.11	---	X	8000	80	X	---
MCCRACKEN	X	---	---	---	X	---
MCCRACKEN	---	X	2.0	---	X	---
MACBETH	X	---	---	---	---	HARD RUBBER
LAB-BUILT	X	---	---	---	X	---
PROSCAN	---	X	11	---	---	---

7. The current version of the McCracken profilograph software has a new filter called a blanking band filter factor. The filter should be set to "0" (off) for the majority of profilograph testing. The filter setting is displayed with the other information at the end of the profilogram. It is intended to be used only on short radius horizontal curves to compensate for the effect of the superelevation. The result of using the filter is a reduction in the longer wavelength features of the profilogram and a possible reduction in the profile index.

E. Maintenance

1. The truss is aluminum and will not rust, but must be stored inside during the winter.

2. Quick-acting clamps may require a drop or two of light oil for free operation and fittings should be greased at least once per year. Do not over-lubricate since this will create a mess and attract dirt.

3. Use rust remover, repaint rusted parts, and wax chrome parts every winter.

4. Check the test tire pressure to be identical to that stenciled on the Profilograph truss prior to testing [usually 170 kPa (25 psi)], but can vary for the manual Ames Profilograph. Hard-Rubber-Tired Profilographs properly calibrated (such as the MacBeth Machine) are also acceptable.

5. Do not force the steering wheel since gears can be stripped. The steering box or linkage can freeze up in cold weather and this is generally when damage occurs.

6. Do not hit curbs, drive over drop-offs, etc. that could damage the machine while turning or maneuvering.

7. Do not tow the Profilograph since the small averaging wheels at both ends of the machine can be damaged.

8. If the Profilograph is in poor condition, it should be repaired and sent to the Central Materials Laboratory for calibration.

F. Test Procedure

1. The contractor (or sub-contractor) responsible for smoothness testing and evaluation shall give the Project Engineer and the DME 48 hours notice prior to testing so the Office of Materials may provide a certified technician for correlation purposes with the contractor.

2. The Profilograph is pushed at walking speed at 1/4 point on new pavements and in the wheel tracks on new bridge decks and bridge deck overlays. See Figure 20. Profilograph propulsion may be provided by personnel pushing manually or by 2-kilowatt (3 horsepower) propulsion units.

3. Pointer use is mandatory. More than one person may be required to hold the back end of the Profilograph exactly at 1/4 point on superelevated or sharp horizontal curves.

4. Slow down walking speed if excessive "spikes" are encountered since this produces a trace, which is difficult to evaluate, and may affect test results.

5. Lift the test wheel, rotate it to take slackness out of the chain, and lower it to the pavement surface at the starting point prior to testing. Lifting the test wheel at the beginning and end of each trace clearly define termini. This may also be accomplished by pulling the recording cable.

6. On short test sections (such as bridge decks) it is usually easier to lift the test wheel to transporting position and push the Profilograph backward to the next wheel track than it is to turn the machine around.

7. Note stationing on the profilogram at least every 1000 ft. (300 m) and preferably every 500 ft. (150 m). Closer station references are highly desirable where possible. This station referencing on the trace is used to accurately locate 1/2 in. (12.7 mm) bumps (or dips) and is less critical if a Profilograph is available during grinding or bump (dip) correction operations. Use landmarks, roadway signs, maintenance markers, or mileposts on Hot Mix Asphalt (HMA) resurfacing projects. Spray paint can be used on the pavement for computer Profilographs to mark the location of 1/2 in. (12.7 mm) bumps (or dips).

8. Completely label both ends of the Profilograph roll and note the stationing and roll number at each end of the roll. Fill out a report form in pencil or pen and place the report around the trace roll with a rubber band. This report insures that the person reducing the trace and reporting results will have all the information necessary.

9. A little dirt or debris will spike out and not affect Profilograph readings, however, excessive mud or caked mud must be removed prior to testing. Anything longer than 2 ft. (0.6 m) may not be considered a spike when reducing the trace. A grader blade will knock concrete crumbs off transverse grooving. This will produce fewer spikes and a better profile trace to accurately reduce.

10. On HMA resurfacing projects, the runout tapers at the beginning and end of project are tested for 1/2 in. (12.7 mm) bumps or dips. See Figure 3. Runout tapers are also tested for 1/2 in. (12.7 mm) bumps or dips at bridges. See Figure 22.

11. Where possible, the Profilograph should start with the front wheel at beginning of the new construction for which the contractor is responsible. See Figure 4.

12. Always test header to header whenever possible stopping the front wheel at the header, and starting at that same location for the next section. The header must be checked for 1/2 in. (12.7 mm) bumps or dips and count. See Figure 5.

13. The 15 ft. to 150 ft. (5 m to 45 m) odd length at the end of a day's run due to barrier fences, machinery, paving not placed yet, etc., should be included in the next day's run. See Figure 6.

14. Side roads will only be tested for count and for 1/2 in. (12.7 mm) bumps and dips if the smoothness specification applies by plan note, and they are 600 ft. (180 m) in length or longer. A distance of 150 ft. (45.7 m) on the side road will be omitted from Profilograph testing for count to exclude returns. This 150 ft. (45.7 m) distance will be measured perpendicular to mainline paving and from edge of pavement to edge of pavement. The Profilograph test wheel should be placed at this location to begin side road testing for count and for 1/2 in. (12.7 mm) bumps and dips. See Figure 7.

15. Acceleration and deceleration tapers are tested as mainline pavement. The end of an entrance ramp is located by the point where the ramp is full lane width. The end of an exit ramp is also located by the point where the ramp is full lane width. The Profilograph is completely on the ramp at these termini points. See Figure 8.

16. Test the wider pavement width on ramps to represent ramp smoothness if the ramp width is placed in more than one pass (such as on HMA resurfacing projects). Testing should be performed as closely to the center of the driving lane of the ramp as possible. If the pavement joint falls exactly at the center of the driving lane of the ramp, then offset 2 ft. (0.6 m) to the right with traffic to test with the Profilograph.

17. When testing over 4 in. (100 mm) expansion joints, fill the space with wood, cover the space with metal (or some other material) so that the small Profilograph wheels can roll over the joint.

18. When testing bridge approaches, push the 25-foot (7.6 m) Profilographs 100 ft. (30 m) on the pavement and 100 ft. (30 m) on the bridge to get enough trace to correctly position the blanking band through the bridge approach area. Only the plan bridge approach length is analyzed (tested for count). See Figure 23. The header at the bridge and at the approach and adjacent pavement are checked for 1/2 in. (12.7 mm) bumps and dips. Grinding is permitted on the bridge deck as directed by the engineer.

19. Since the Profilograph is symmetrical, testing may be performed in either direction of traffic or paving (or resurfacing). It is desirable to test in the direction of traffic, however. It is also highly desirable to reduce traces in the direction of traffic wherever possible. While this is easy to do with manual Profilograph machines and reduction methods, it is recognized that Computer Profilographs may have problems meeting these criteria. It is not the intention to penalize the use of Computer Profilographs.

G. Trace Reduction & Bump Locating Procedure

1. The red (or other contrasting color) profile line is mandatory on all PCC pavement sections involving price adjustments or bonus payments, which are manually reduced. No outlining should be used when using ProScan or other computerized units. This outlining procedure removes spikes and minor deviations caused by rocks, texturing, dirt or transverse grooving. See Figure 9. To outline a trace, care should be taken to average normal spiking. In some cases, spiking will be severe such as when faulting is encountered. The recording wheel will bounce and cause a larger spike above the actual profile line. This should be taken into account when drawing the red line.

   When testing an HMA overlay project, a red pen can be used in the recording box to make trace reduction easier. HMA surfaces generally do not produce enough spiking to affect trace reduction results, but the red ink contrasts with the blanking band, thus easing judgment calls above or below the scribed lines on the blanking band.

2. Use a 1/2 in. (12.7 mm) bump template to locate bumps or dips for removal. A 3/10 in. (7.6 mm) bump template may be specified by contract documents to locate bumps or dips for acceptance. At each prominent bump or dip on the profile trace, place the template so that the small holes or scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the dip or indicated bump. The line on the template need not be horizontal. With a sharp pencil draw a line using the narrow slot in the template (or edge) as a guide. Any portion of the trace extending above or below this line will indicate the approximate length and height of the bump or dip in excess of the specification.

   There may be instances where the distance between easily recognizable low points is less than 1 in. (25 ft.) [25.4 mm (7.6 m)]. In such cases a shorter chord length shall be used in making the scribed line on the template tangent to the trace at the low points. It is the intent, however, of this requirement that the baseline for measuring the height of bumps or dips will be as nearly 25 feet (1 inch) [7.6 m (25.4 mm)] as possible, but in no case to exceed this value. When the distance between prominent low points is greater than 25 feet (1 inch) [7.6 m (25.4 mm)] make the ends of the scribed line intersect the profile trace when the template is in a nearly horizontal position. A few examples of the procedure are shown in the lower portion of Figure 12. Also see Figure 9.

3. Place the blanking band over the profile to remove or "blank out" as much of the profile as possible. When this is done, scallops above and below the blanking band usually will be approximately balanced. See Figure 10.

   The profile trace will move from a generally horizontal position when going around superelevated curves making it impossible to blank out the central portion of the trace without shifting the scale. When such conditions occur the profile should be broken into short sections and the blanking band repositioned on each section while counting as shown in the upper part of Figure 12.

Note superelevated curves on the trace while testing to later look for this condition when reducing the trace. Note any special conditions on urban paving which may affect the trace and for which the contractor should not be penalized.

4. Certified Profilograph reports shall have the following distribution and be submitted as stated in Standard Specification 2316.03 for timely correlation testing by the DOT:

   a. RCE, County or City Engineer
   b. District Materials Engineer (DME)
   c. Special Investigations Engineer
   d. Contractor/Subcontractor (For Iowa DOT personnel)

5. Begin evaluating each trace from the same point on the road so that segments representing the same length of road can be aligned on the test report form. Measure and total the height of all the scallops appearing both above and below the blanking band, measuring each scallop to the nearest 0.05 in. (1.3 mm). Round down as well as up. Do not count a scallop as 0.05 in. (1.3 mm) just because you see the profile line or there is space under the line.

   Short sections of the profile line may be visible outside the blanking band, but unless they project 0.03 in. (0.8 mm or more and extend longitudinally for two feet [0.08 in. (2 mm) on the profilogram] or more, they are not included in the count. See Figure 11 for illustration of these special conditions. Spikes are not counted. Double-peaked scallops are only counted once as the highest peak.

   Write the total count in millimeters (inches) on the profilogram above the profile line (toward the center of the segment) and circle it. Outline the position of the blanking band when reducing the trace for later repositioning to check trace reduction procedure. Do not rotate the blanking band about the last end position when moving forward with trace reduction. Blank out as much of the profile as possible for each segment. See Figure 13.

   When a scallop occurs at the end of the blanking band, count the scallop only once. Place the scallop in the 0.1-mile (161 m) segment where the peak is highest. See Figure 14.

   Always use the measured trace length in computations. This length will not agree exactly with distance by subtracting stationing. Always use $\pm$ after the ending station on the report.

6. The last segment counted is generally not an even 0.1-mile (161 m). If not, its length should be scaled to determine its length in kilometers (miles). For the example shown below, the odd length segment measures 7.60 in. (193 mm) in length.

$$\frac{193\ \text{mm} \times 0.3\ \text{m/mm}}{1{,}000\ \text{m/km}} = 0.58\ \text{km} \qquad \frac{7.60\ \text{in.} \times 25\ \text{ft./in.}}{5{,}280\ \text{ft./mi.}} = 0.036\ \text{mi.}$$

If the odd length segment is less than 0.047 miles (250 feet) [0.076 km (76.2 m)] it is added to and included in the evaluation of the adjacent segment in that section. If the odd length segment is more than 0.047 miles (0.076 km) it is evaluated on its own. See Figure 15.

The Profile Index is determined as "millimeters per kilometer (inches per mile) in excess of the 0.20 in. (5.0 mm) blanking band," but is simply called the Profile Index. The procedure for converting counts [meters (inches) of roughness] to Profile Indices is illustrated in Figure 15. For 0.1-mile (160.9 m) segments, the Profile Index can be determined from the counts [inches (meters) of roughness] by moving the decimal place one position to the right. For odd length segments, the Profile Index is determined by dividing the counts by the segment length in miles (kilometers). The weighted average for a day's run is determined by dividing the total counts [inches (millimeters) of roughness] for the day's run by the total length in miles (kilometers) of the day's run.

H. Reporting

1. Laboratory numbers must be continuous and increasing numerically as testing is performed. Laboratory numbers will change on revised reports and stay the same on corrected reports. Revised reports are due to contractor grinding corrections, and corrected reports are due to Iowa DOT or contractor reporting error corrections. Referencing of Laboratory Numbers and trace roll numbers to previous reports is extremely important. Contractors should put their company names at the top of Iowa DOT Form #821301 and have a printer reproduce new forms. Remove "District Materials Engineer" at bottom of form and Iowa DOT name and logo.

2. An example of a completed report form is shown in Figure 16. Always start with a full 0.10-mile (161 m) segment and align both directions or lanes on the form. Entitle the first report "Preliminary" even if no pavement corrections are required.

3. The reverse side of Form #821301 is for bridge decks. An example of a completed bridge deck monitor report is shown in Figure 17.

4. Certified Profilograph Reports shall have the following distribution:

    a. RCE, County or City Engineer
    b. District Materials Engineer
    c. Special Investigations Engineer (will make Ames distribution)
    d. Contractor (For Iowa DOT Personnel)

I. Certification

1. Contractors must furnish and certify Profilograph test reports. A trained, certified person shall do the testing and evaluation and the evaluation shall be certified.

2. Profile traces (profilograms) become part of the RCE (County or City Engineer) permanent project records.

3. Basis of certification is attendance at a training school and passing a test. Each attendee passing the test will receive a certification card, and his/her name will be placed on the Iowa DOT computerized certification list. Certifications shall be renewed every five (5) years and shall be renewed within three months after the expiration date. Basis of renewal is to again attend a training school and to pass a test. The responsibility for enrolling in a training school for recertification shall be in the hands of the certified individual. Applications should be sent to the Technical Training & Certification Program Coordinator.

4. Certification and de-certification procedures are covered in IM 213.

5. When a contractor is decertified to issue Profilograph Reports, the company's reports will not be recognized until the contractor makes corrections in testing, trace reduction and reporting to the satisfaction of the engineer.

6. The certified Profilograph person who reduced the trace must sign each certified Profilograph test report.

7. Each certified Profilograph test report must also include the following certification statement:

   "This is to certify that all testing and trace reduction herein described has been performed according to applicable contract specifications and requirements."

8. Iowa DOT Profilograph monitor test reports must include the certification signature, but not the certification statement.

J. Metrication

1. You may encounter some projects requiring metrication. Use a soft conversion. That is, reduce traces using the English System like you always have, but multiply the inches per mile numbers by 15.786. Filling in the middle column is optional to accommodate computer profilographs. You need not report both the English System and the Metric System on the same report form. Circle either mm/km or inches/mile under the Profile Index Column. Carry mileage to 3 decimal places; in./mi. to 2 decimal places; and mm/km to 1 decimal place.

2. Conversion factors are as follows:

   in./mi. to mm/km, multiply by 15.786
   inch to mm, multiply by 25.4
   mile to kilometer, multiply by 1.609347
   feet to meter, multiply by 0.3048006

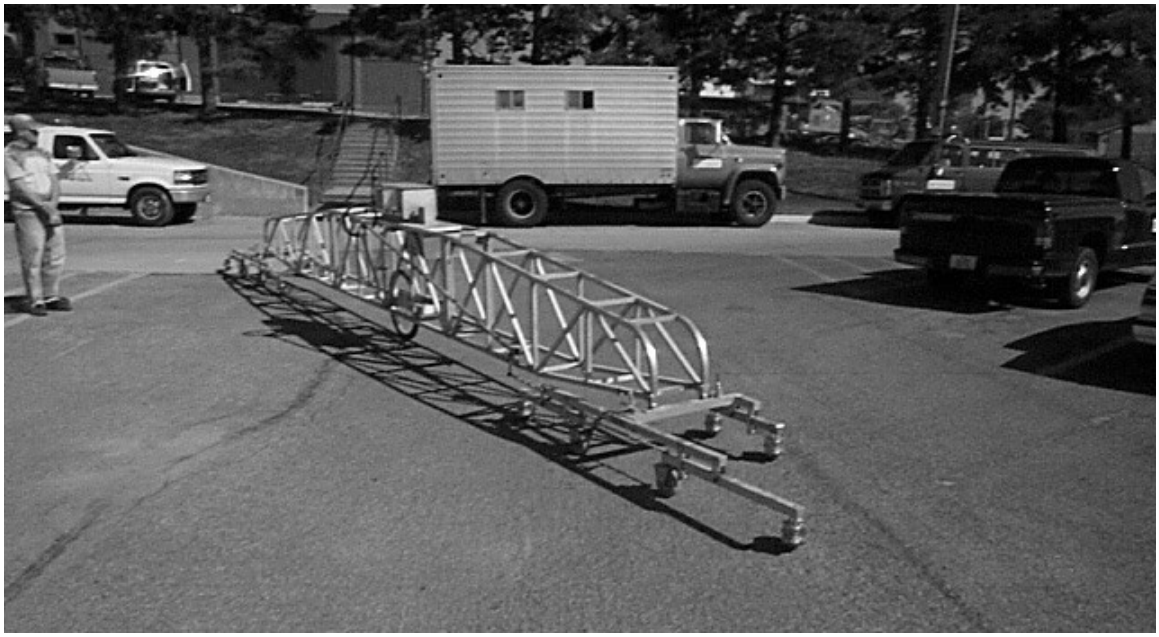


Figure #1. 25-Foot (7.6-Meter) Profilograph

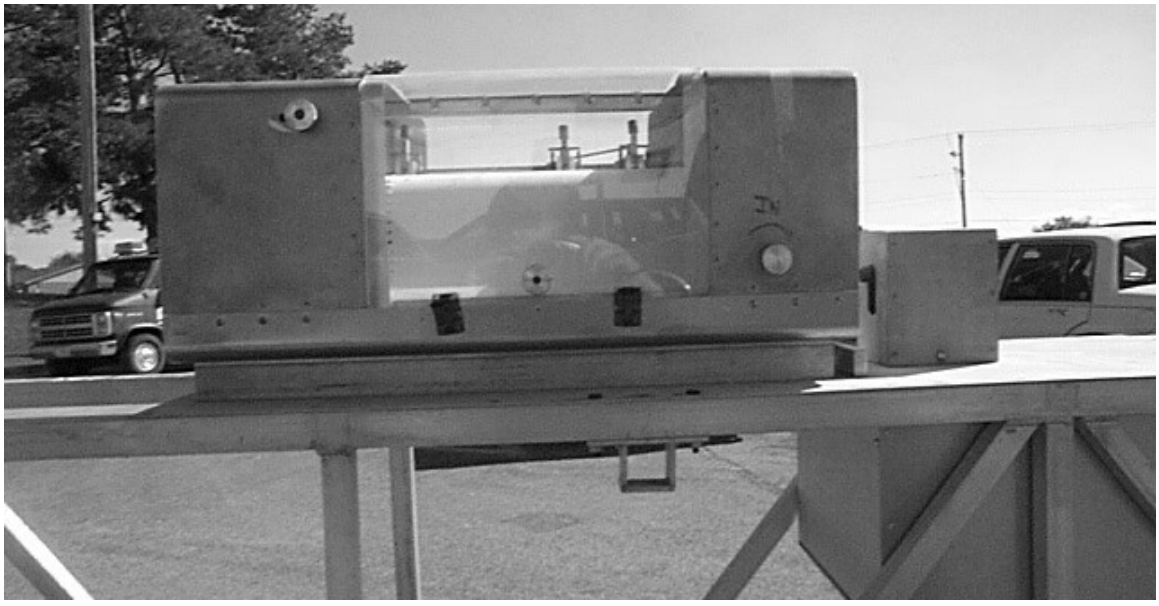
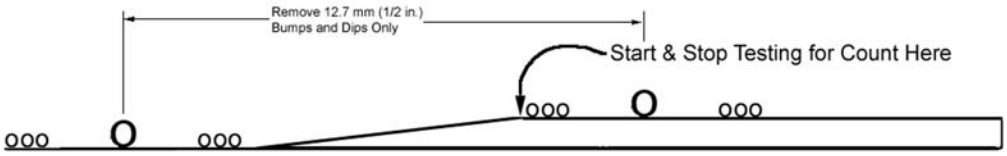


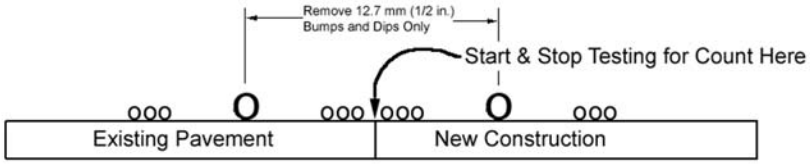
Figure #2. 25-Foot (7.6-Meter) Profilograph Recording Box

Figure 3



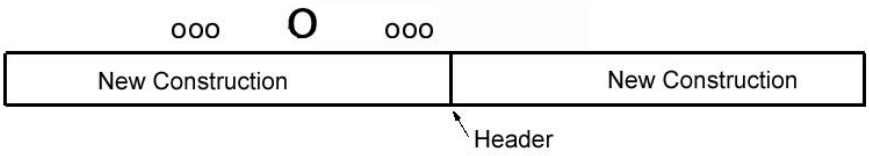
AC RUNOUT TAPERS

Figure 4



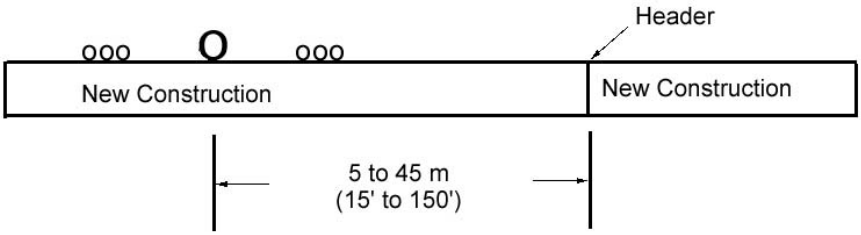
ALL OTHER NEW CONSTRUCTION

Figure 5



Test Header to Header whenever possible.
Check Header for 12.7 mm (1/2") Bumps or Dips and count.

Figure 6



Add this segment to next day's paving when Header to Header testing is not possible and to check for 12.7 mm (1/2") bumps or dips and count.

Figure 7

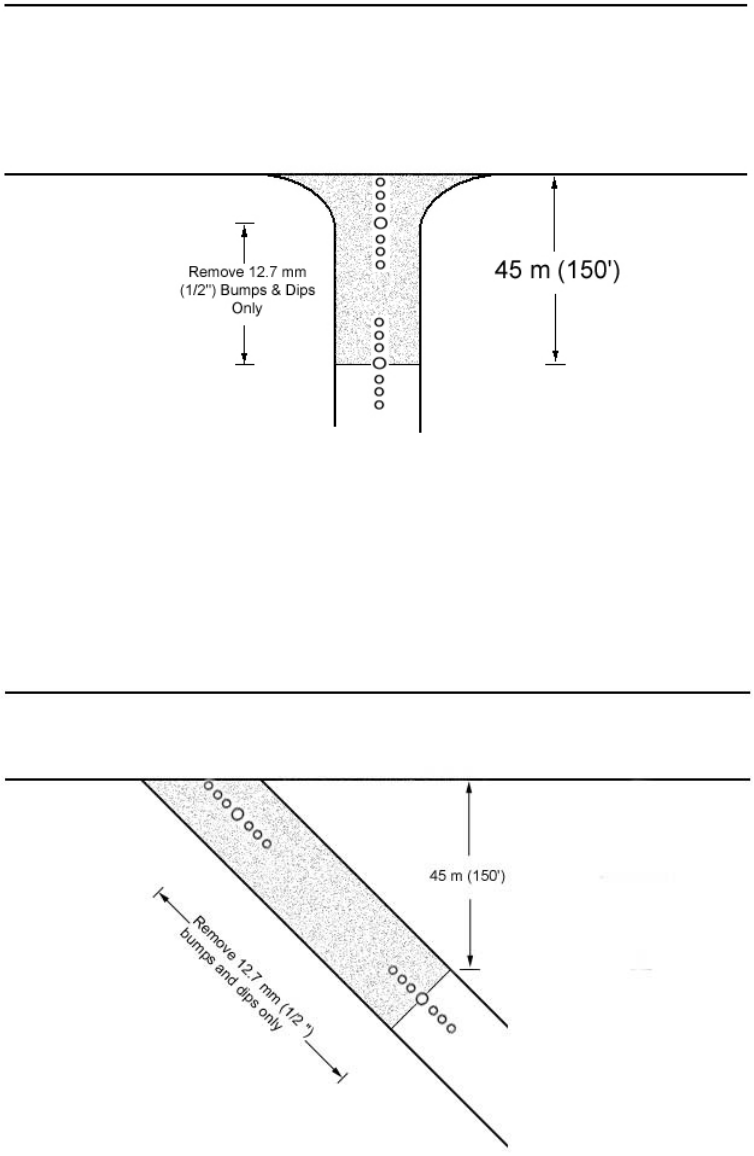

Remove 12.7 mm
(1/2") Bumps & Dips
Only
45 m (150')
45 m (150')
Remove 12.7 mm (1/2 ")
bumps and dips only

Figure 8
Ramps

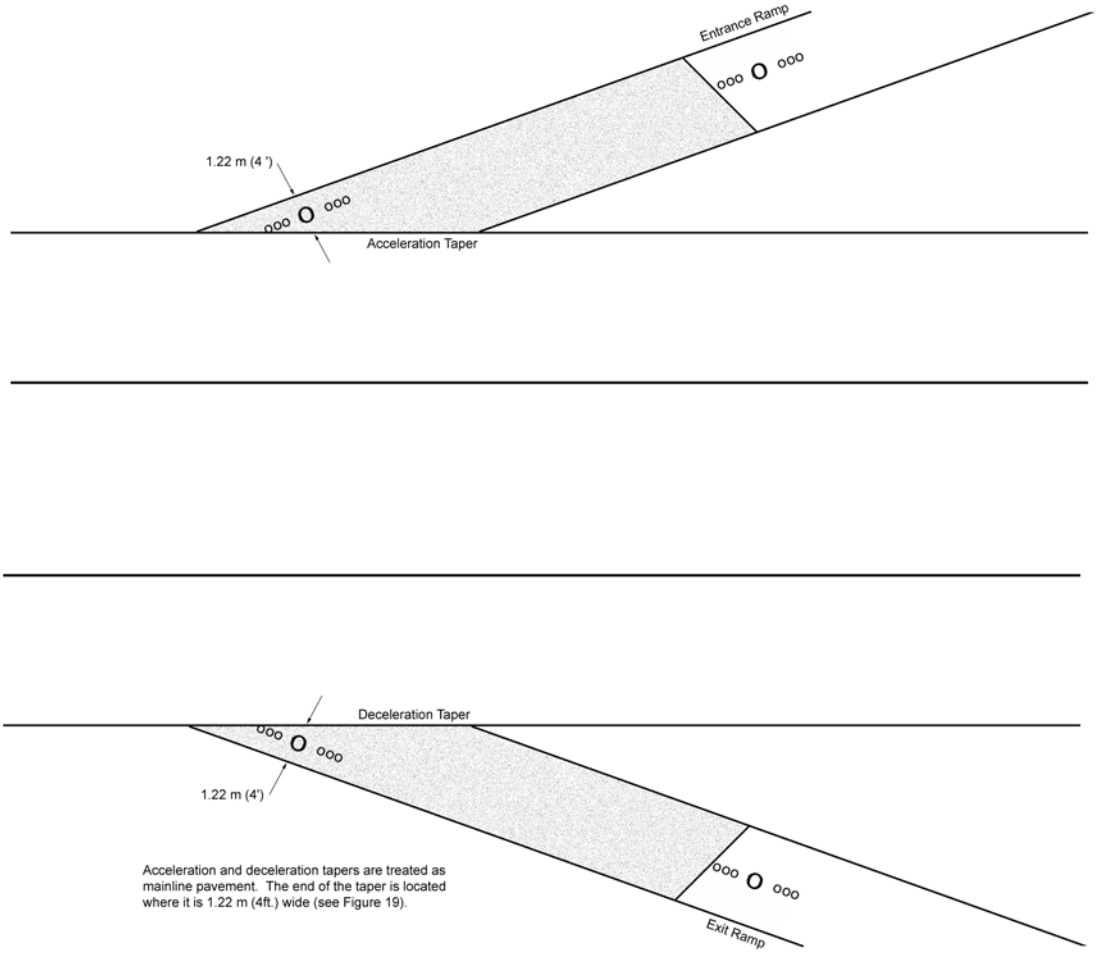


Figure 9
Trace Outline & 12.7 mm (1/2") Bump Location

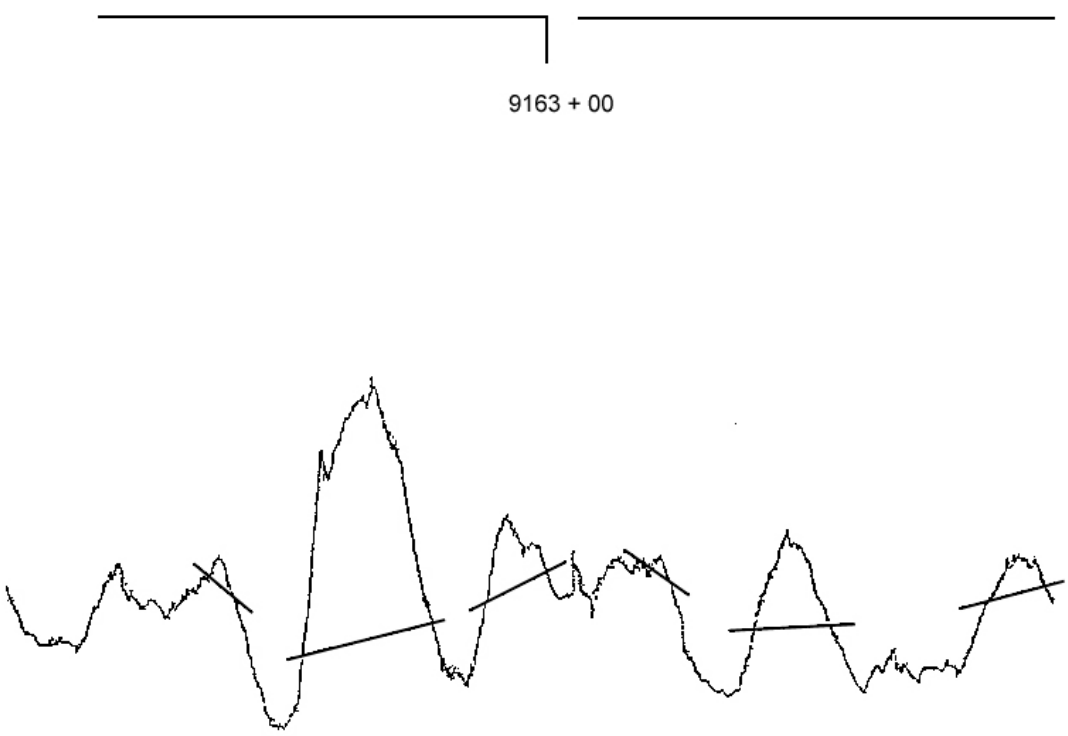


Figure #10

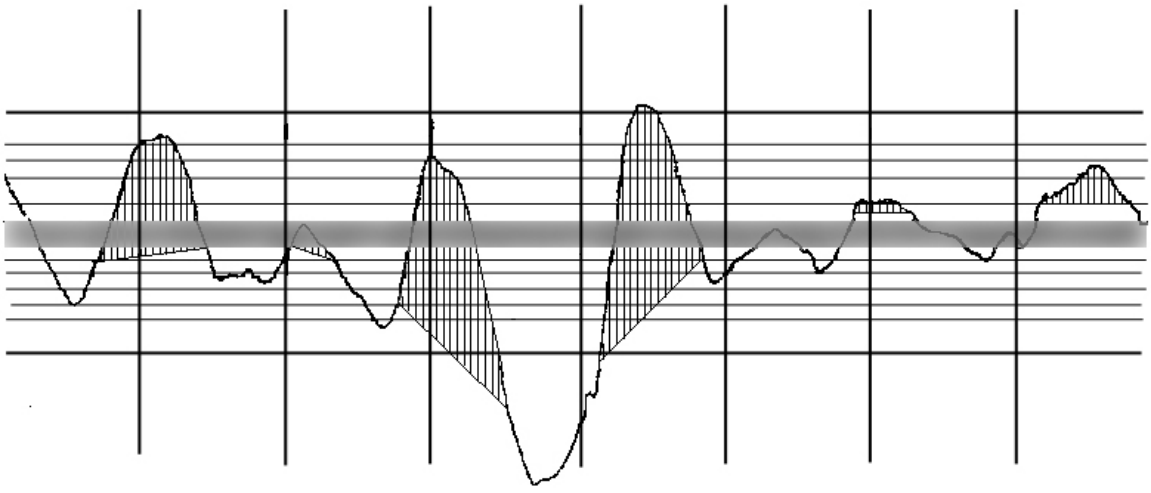
BLANKING BAND

9163 + 00

$$\frac{144.8\ \text{mm}}{\frac{162.6\ \text{mm} \quad 0.3\ \text{m/mm}}{1{,}000\ \mu / k\mu}} = 2968.4\ \text{mm/km}$$

$$\frac{5.70\ \text{Inches}}{\frac{6.40\ \text{Inches} \quad 25\ \text{Feet/Inch}}{5{,}280\ \text{Feet/Mile}}} = 188.10\ \text{In./Mi.}$$

15.24 mm (.60 in.) | 11.43 mm (.45 in.) | 20.32 mm (.80 in.) | 3.81 mm (.15 in.) | 8.89 mm (.35 in.)



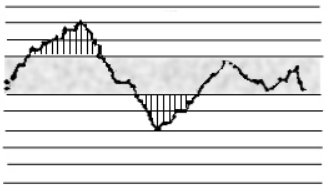
10.16 mm (.40 in.) | 6.35 mm (.25 in.) | 13.97 mm (.55 in.) | 40.64 mm (1.60 in.) | 6.35 mm (.25 in.) | 5.08 mm (.20 in.) | 2.54 mm (.10 in.)

Figure 11

TYPICAL AND SPECIAL CONDITIONS

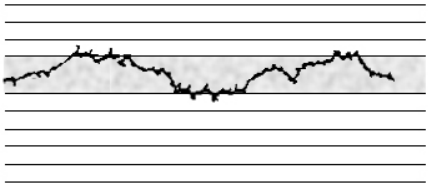
TYPICAL CONDITIONS

Scallops are areas
enclosed by profile
line and blanking band.
(Shown crosshatched in this sketch)



A

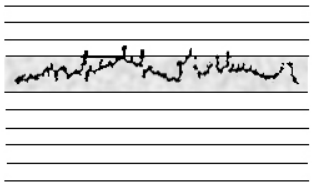
Small projections which
are not included in the count



B

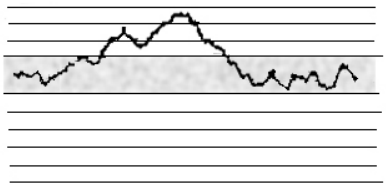
SPECIAL CONDITIONS

Rock or dirt on
the pavement
(not counted).



C

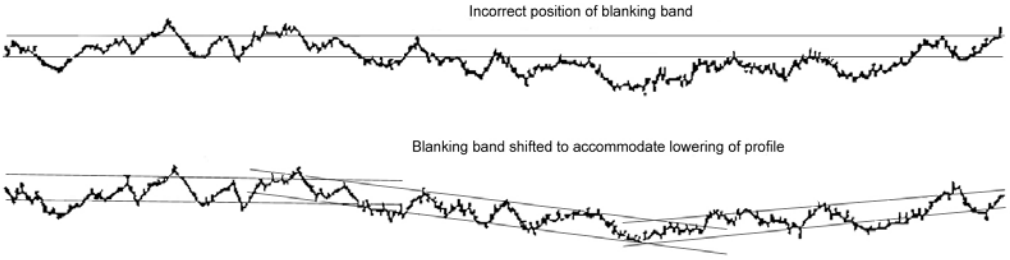
Double peaked scallop
(Only the higest part counted).



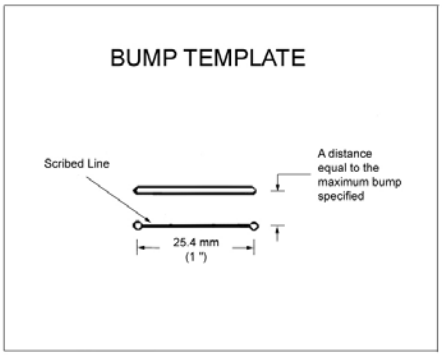
D

Figure 12
SUPERELEVATED CURVES & 12.7 MM (1/2") BUMP LOCATION

METHOD OF COUNTING WHEN POSITION OF PROFILE SHIFTS AS IT MAY WHEN ROUNDING SHORT RADIUS CURVES WITH SUPERELEVATION



METHOD OF PLACING TEMPLATE WHEN LOCATING BUMPS TO BE REDUCED



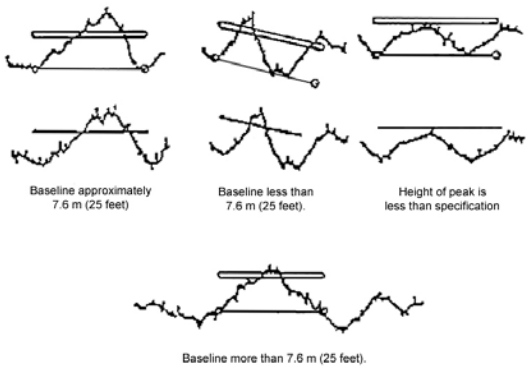


Figure #13

BLANKING BAND ABOUT LAST END POINT

Blank out as much profile as possible for each segment.
No continuity between segments is necessary.

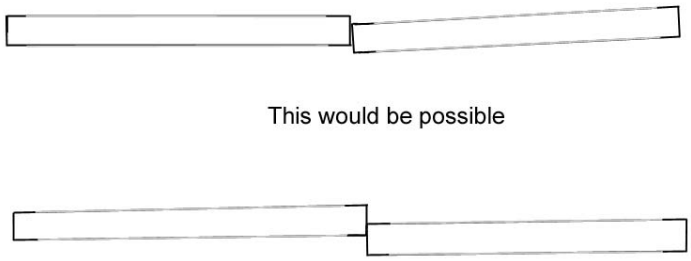


Figure #14

SCALLOPS OCCURRING AT END OF BLANKING BAND

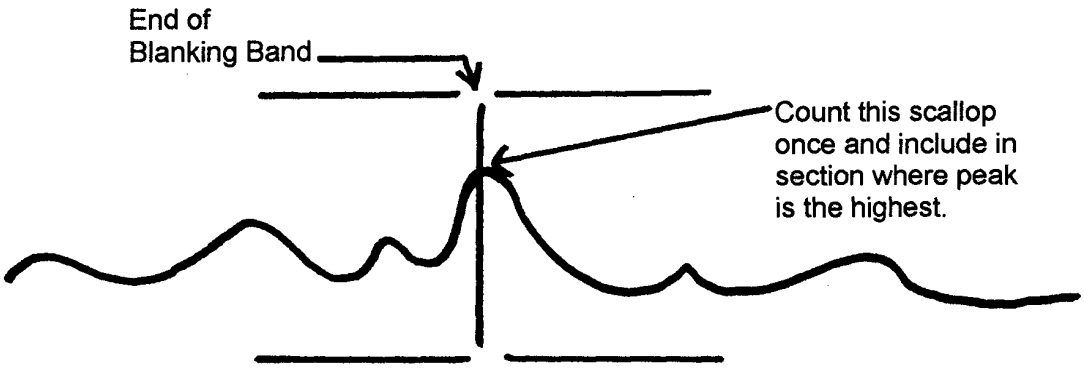


Figure #15

SAMPLE CALCULATIONS

SEGMENT LENGTH KILOMETERS (MILES)	MILLIMETERS (IN.) OF ROUGHNESS SHOWN ON TRACE	REPORTED ROUGHNESS MILLIMETERS/KILOMETERS (INCHES/MILES)
0.16 (0.1)	64.8 (2.55)	405.0 (25.50)
0.16 (0.1)	77.6 (3.05)	484.4 (30.50)
0.16 (0.1)	116.8 (4.60)	730.0 (46.00)
0.16 (0.1)	20.3 (0.80)	126.9 (8.00)
0.16 (0.1)	39.4 (1.55)	246.3 (15.50)
0.16 (0.1)	147.3 (5.80)	920.6 (58.00)
0.16 (0.1)	67.3 (2.65)	420.6 (26.50)
0.16 (0.1)	12.7 (0.50)	79.4 (5.00)
0.22 (0.136)	214.6 (8.45)	975.5 (62.13)[1]
1.50 (0.936)	760.7 (29.95)	507.1 (32.00)[2]

1. $\frac{214.6\ mm}{0.22\ \text{km}} = 975.5\ \text{mm/km}$ (OR) $\frac{8.45\ \text{inches}}{0.136\ \text{miles}} = 62.13\ \text{in./mi.}$

2. $\frac{760.7\ \text{mm}}{1.50\ \text{km}} = 507.1\ \text{mm/km}$ (OR) $\frac{29.95\ \text{inches}}{0.936\ \text{miles}} = 32.00\ \text{in./mi.}$

Figure #16
PAVEMENT TEST REPORT

FRED CARLSON CO.
BOX 46 ■ DECORAH, IOWA 52101
PHONE (319) 382-4242

7.6 ■ CALIFORNIA PROFILOGRAPH

☐ Revised Report
Changes Lab. No. _____

☐ For Information Only ☐ Preliminary ☐ Intermediate ☐ Final

Lab No. Johnson 1 Route No. I-80 Project No. IM-80-7(59)247-13-52
Date Reported 6-24-93 Date Paved 6-22-93 County Johnson
Tested At ☒ ½ Point ☐ Wheel Track Contractor _____
Tested By Allen Date 6-23-93
Trace Reduced By Westfield Date 6-24-93

☒ Primary Schedule A ☐ PCC Slip Form ☒ ACC Paving
☐ Primary Schedule B ☐ PCC Fixed Form ☐ ACC Resurfacing
☐ Secondary ☐ PCC Bonded Overlay ☐ ACC Patches
☐ Municipal ☐ PCC Unbonded Overlay
☐ Other ☐ PCC Patches

Roadway Type: ☐ 2-Lane ☒ 4-Lane ☐ Ramp Other _____

Northbound ☐ Eastbound ← Direction → ☐ Southbound ☐ Westbound
☒ Inside Lane ← (4-Lane Only) → ☒ Outside Lane

Length km (Miles)	Measured Roughness mm (Inches)	Profile Index mm/km (Inches/Miles)	Location (Station)	Length km (Miles)	Measured Roughness mm (Inches)	Profile Index mm/km (Inches/Miles)
0.16(.100)	63.5(2.50)	396.9(25.00)	± 1106+16	0.16(.100)	34.3(1.35)	214.4(13.50)
0.16(.100)	27.9(1.10)	174.4(11.00)		0.16(.100)	12.7(.50)	79.4(5.00)
0.16(.100)	19.1(.75)	119.4(7.50)		0.16(.100)	16.5(.65)	103.1(6.50)
0.16(.100)	30.5(1.20)	190.6(12.00)		0.16(.100)	27.9(1.10)	174.4(11.00)
0.09(.057)	5.1(.20)	56.4(3.51)	±1130+50	0.09(.057)	7.6(.30)	84.4(5.26)
0.73(.457)	146.1(5.75)	200.1(12.58)		0.73(.457)	99.0(3.90)	135.6(8.53)

This is to certify that all testing and trace reduction herin described has been performed according to applicable contract specifications and requirments.

Station ← 12.7mm (½") Bump Locations → None Station

ies

Figure #17
MONITOR REPORT

Iowa Department of Transportation

Iowa Transportation Center Materials

7.6 METER CALIFORNIA PROFILOGRAPH

[X] Revised Report
Changes Lab. No. 2

[X] New Bridge Deck [ ] Bridge Deck Overlay

[ ] For Information Only [ ] Preliminary [ ] Intermediate [X] Final

Lab No. RJC2 Route No. Polk S-27 Project No. IR-80-5(129)149 Design No. 2391
Date Reported 5-5-93 Date Poured 9-17-92 to 11-11-92 County Polk
Tested At: Wheel Tracks Contractor Cramer and Assoc., Inc.
Tested By Steve - Cedar Valley Corp. Date 5-3-93
Trace Reduced By Robert Cramer Date 5-3-93

Roadway Type: [X] 2-Lane [ ] 4-Lane [ ] Ramp Other

INSIDE WHEEL TRACK				OUTSIDE WHEEL TRACK		
Length km (Miles)	Measured Roughness mm (Inches)	Profile Index mm/km (Inches/Miles)	Location (Station)	Length km (Miles)	Measured Roughness mm (Inches)	Profile Index mm/km (Inches/Miles)
INSIDE WHEELTRACK				OUTSIDE WHEELTRACK		
0.06 (0.036)	14.0(0.55)	233.3(15.28)	North Bound Lane	0.06(0.036)	7.62(0.30)	127.0(8.33)

$$\text{AVERAGE} = \frac{14.0 + 7.62}{.06 + .06} = 180.2 \text{ mm/km}$$

$$\text{AVERAGE} = \frac{0.85}{0.072} = 11.81 \text{ in/mi}$$

Station ← 12.7mm (½") Bump Locations or 12.7mm (½") Dip Locations → Station

This is to certify that all testing and trace reduction herein described has been performed according to applicable contract specifications and requirements.

Copies

Iowa Transportation Center Materials Engineer

Figure 18

EXPANSION JOINTS ON
BRIDGE DECKS

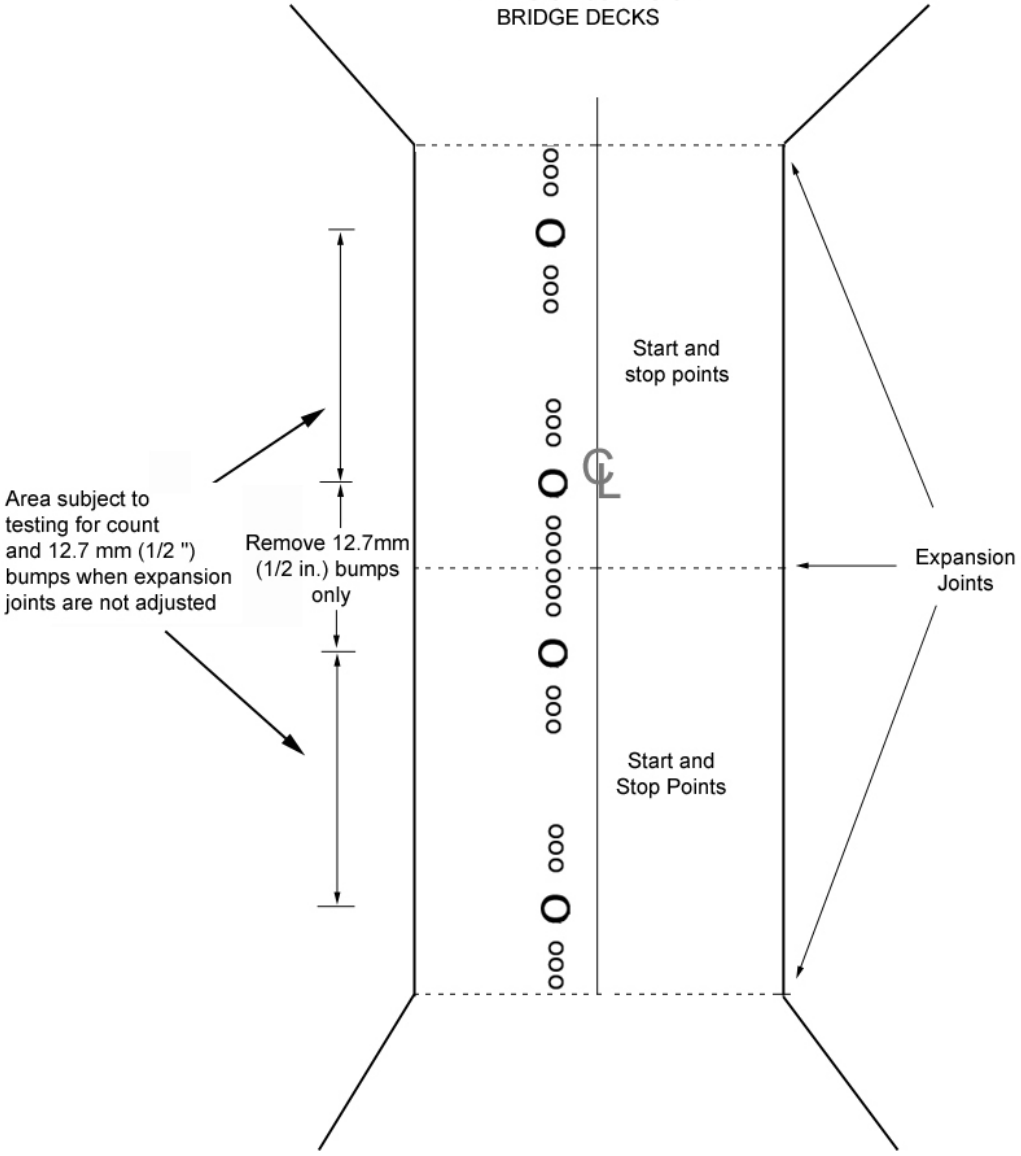


Figure #19

TRANSITION AREAS (LANE TAPER)

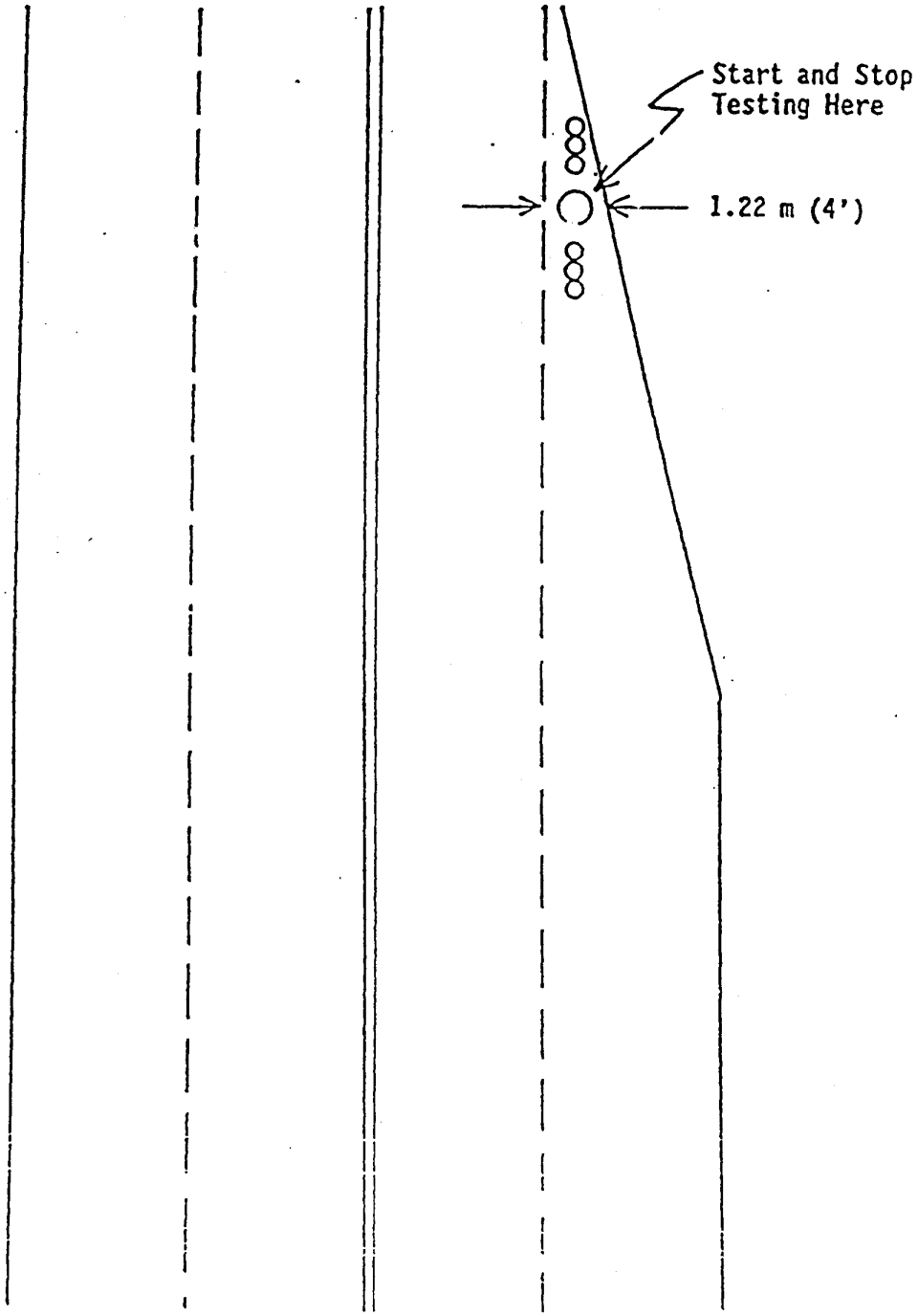


Figure 20

BRIDGE DECK AND APPROACHES

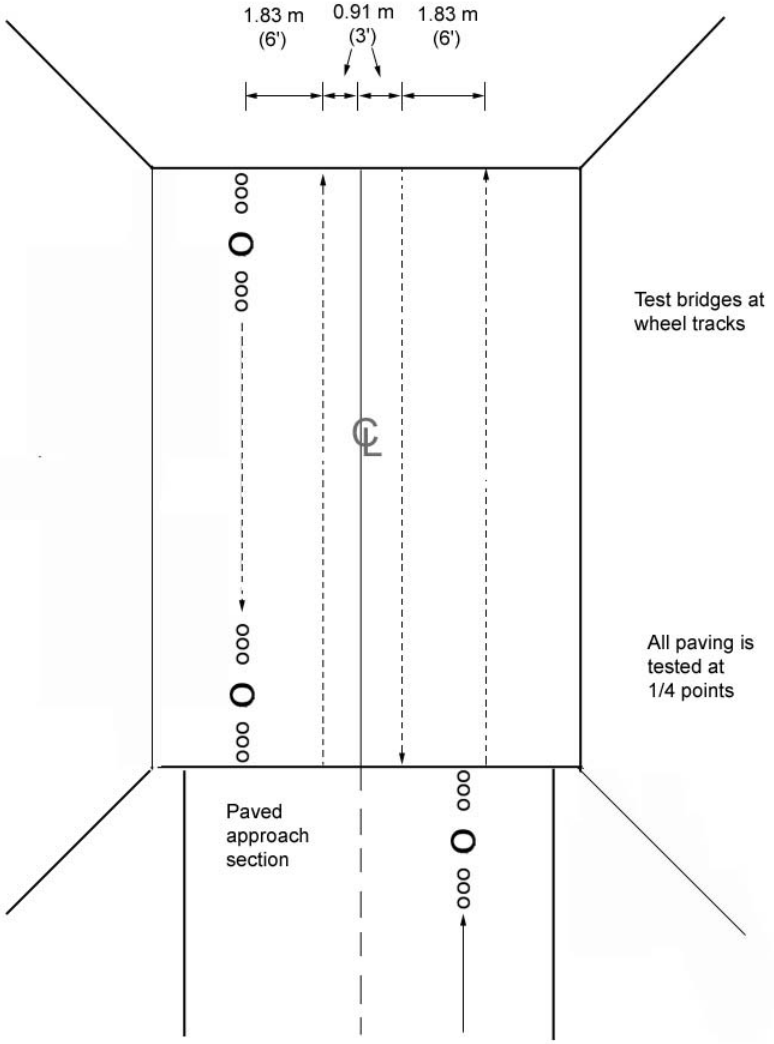
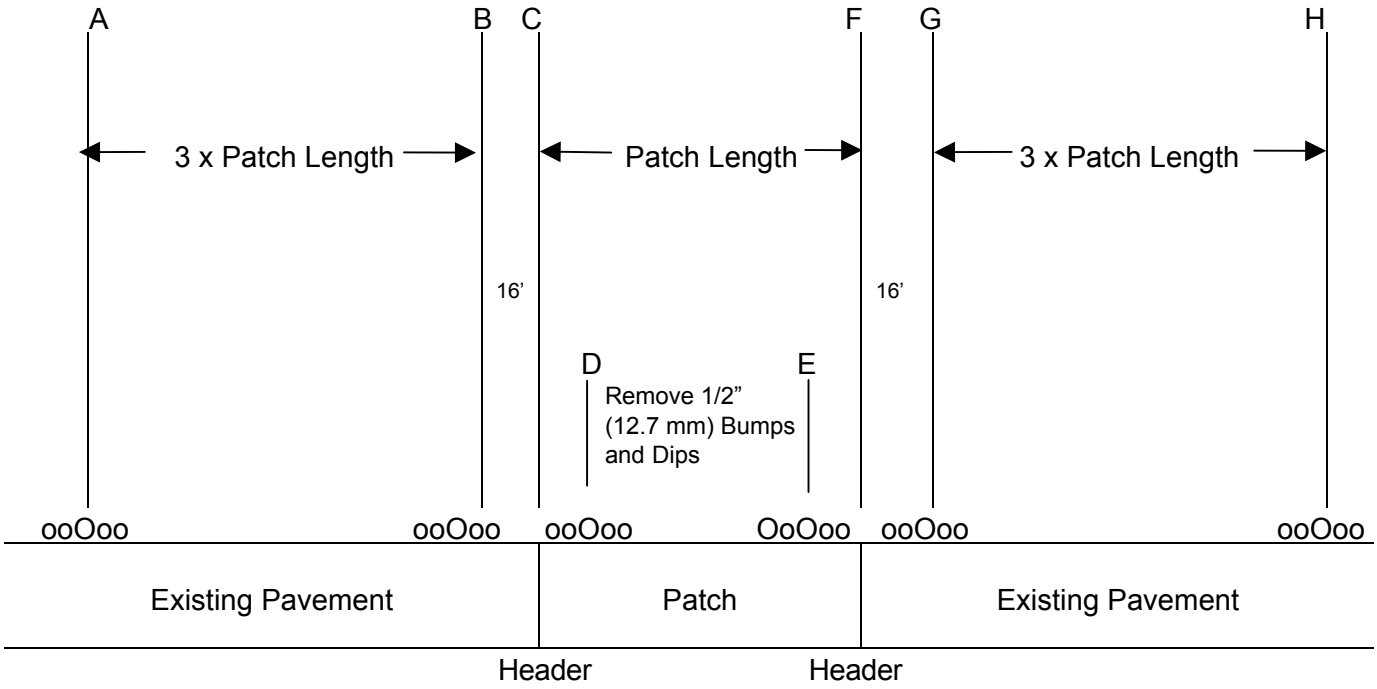


Figure #21



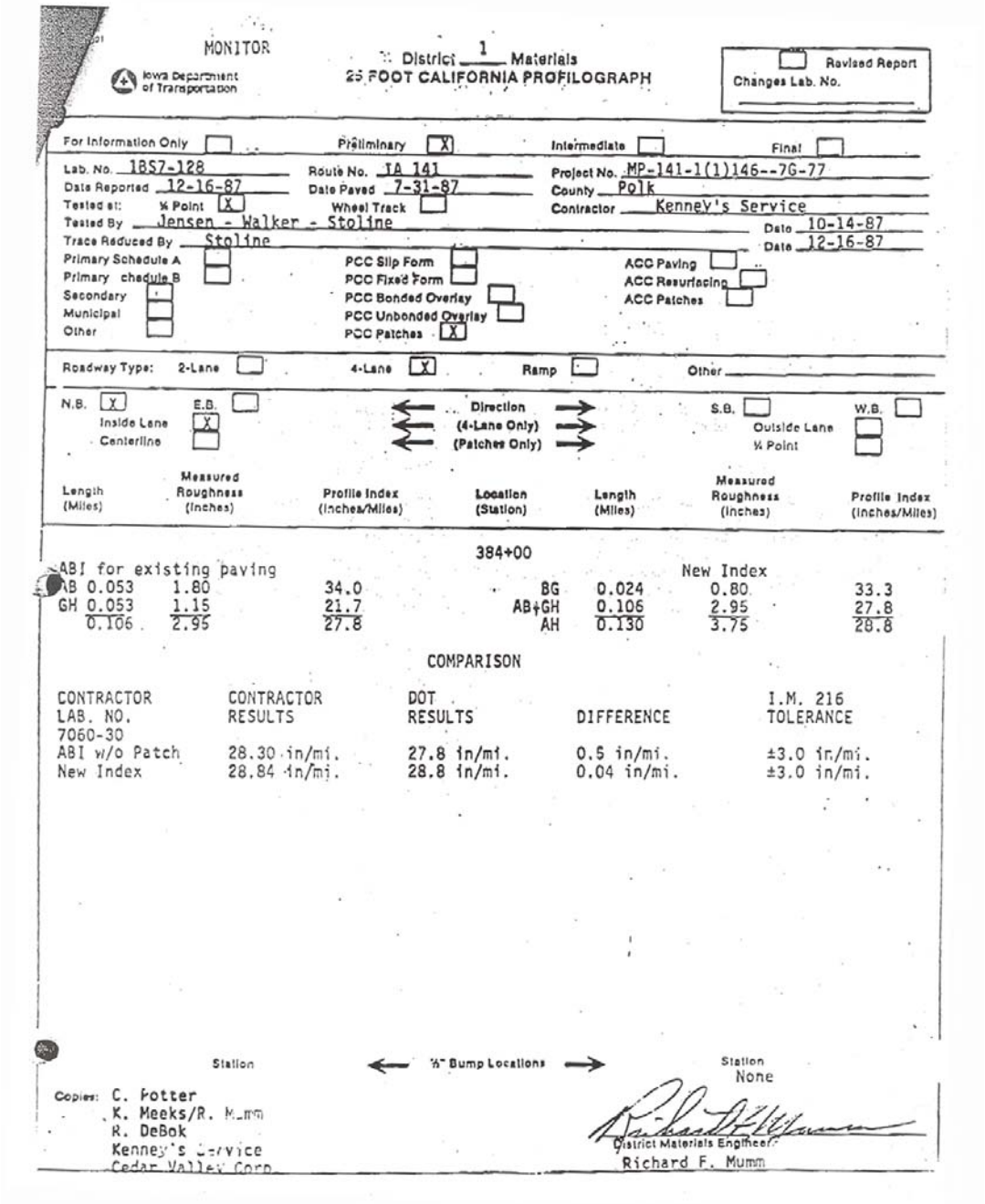
Patch Testing Procedure Specification 2529.10

Compare the index of Line AH to the index of the ABI

$$ABI = \frac{AB + GH}{2}$$

Correct Smoothness between line BG

Figure #21A



MONITOR

Iowa Department of Transportation

District 1 Materials

25 FOOT CALIFORNIA PROFILOGRAPH

☐ Revised Report
Changes Lab. No. _____

For Information Only ☐ Preliminary ☒ Intermediate ☐ Final ☐

Lab. No. IBS7-128 Route No. IA 141 Project No. MP-141-1(1)146--7G-77
Date Reported 12-16-87 Date Paved 7-31-87 County Polk
Tested at: ¼ Point ☒ Wheel Track ☐ Contractor Kenney's Service
Tested By Jensen - Walker - Stoline Date 10-14-87
Trace Reduced By Stoline Date 12-16-87

Primary Schedule A ☐ PCC Slip Form ☐ ACC Paving ☐
Primary chedule B ☐ PCC Fixed Form ☐ ACC Resurfacing ☐
Secondary ☐ PCC Bonded Overlay ☐ ACC Patches ☐
Municipal ☐ PCC Unbonded Overlay ☐
Other ☐ PCC Patches ☒

Roadway Type: 2-Lane ☐ 4-Lane ☒ Ramp ☐ Other _____

N.B. ☒ E.B. ☐ ← Direction → S.B. ☐ W.B. ☐
Inside Lane ☒ (4-Lane Only) → Outside Lane ☐
Centerline ☐ (Patches Only) → ¼ Point ☐

Length (Miles)	Measured Roughness (Inches)	Profile Index (Inches/Miles)	Location (Station)	Length (Miles)	Measured Roughness (Inches)	Profile Index (Inches/Miles)
			384+00			
ABI for existing paving					New Index	
AB 0.053	1.80	34.0	BG	0.024	0.80	33.3
GH 0.053	1.15	21.7	AB+GH	0.106	2.95	27.8
0.106	2.95	27.8	AH	0.130	3.75	28.8

COMPARISON

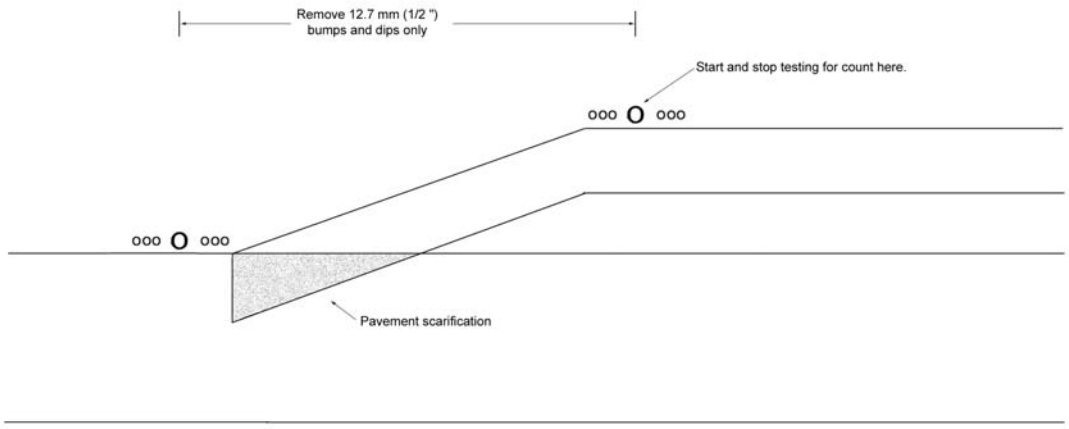
CONTRACTOR LAB. NO. 7060-30	CONTRACTOR RESULTS	DOT RESULTS	DIFFERENCE	I.M. 216 TOLERANCE
ABI w/o Patch	28.30 in/mi.	27.8 in/mi.	0.5 in/mi.	±3.0 in/mi.
New Index	28.84 in/mi.	28.8 in/mi.	0.04 in/mi.	±3.0 in/mi.

Station ← "A" Bump Locations → Station None

Copies: C. Potter
K. Meeks/R. Mumm
R. DeBok
Kenney's Service
Cedar Valley Corp.

District Materials Engineer
Richard F. Mumm

Figure 22
Multiple Lift Overlay



HMA Surface Course Butted Into Existing Pavement.
Bridge Abutment, or Approach Section.

On HMA Resurfacing projects, areas with less than two nominal design lift thickness due to binder taper or butted in surface lift are tested for 1/2 in. (12.7mm) bumps and dips.

Figure #23

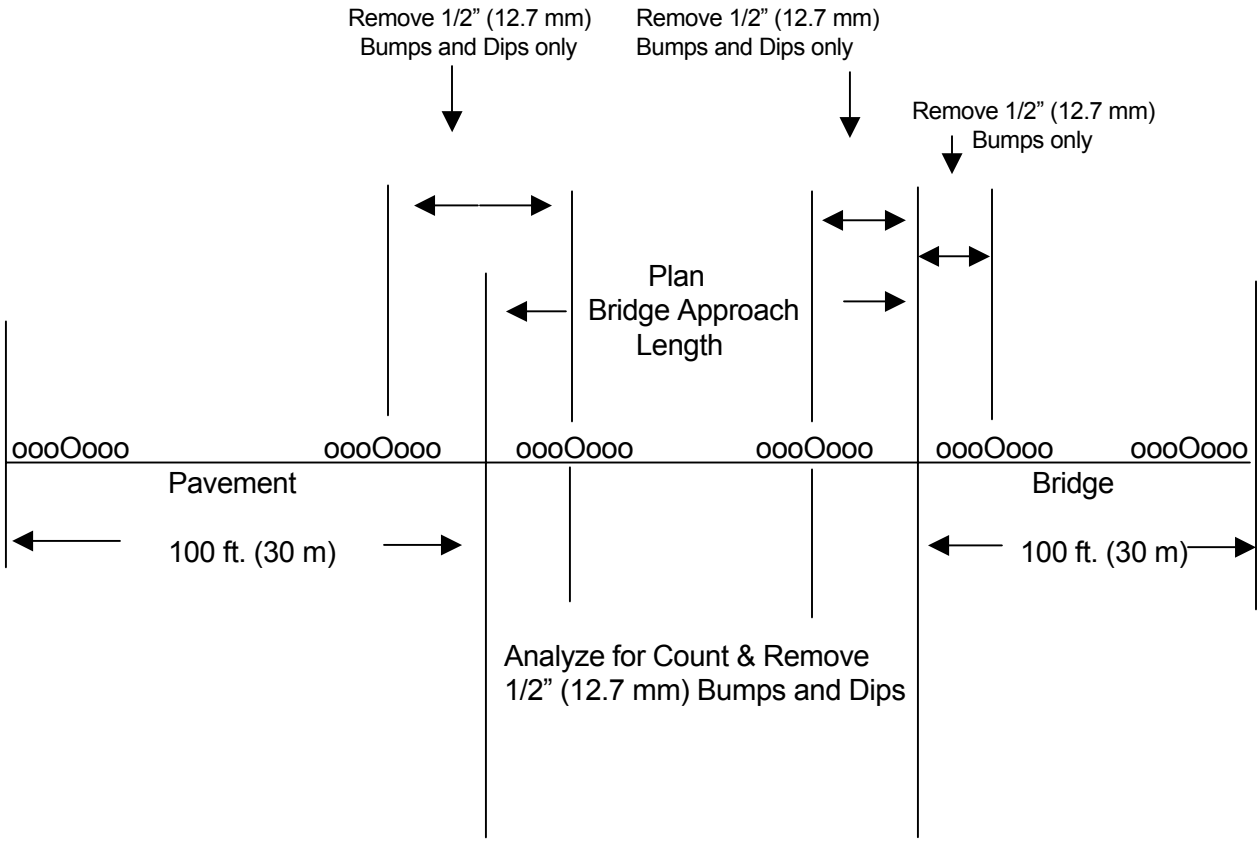

Remove 1/2" (12.7 mm)
Bumps and Dips only
Remove 1/2" (12.7 mm)
Bumps and Dips only
Remove 1/2" (12.7 mm)
Bumps only
Plan
Bridge Approach
Length
oooOooo
oooOooo
oooOooo
oooOooo
oooOooo
oooOooo
Pavement
Bridge
100 ft. (30 m)
100 ft. (30 m)
Analyze for Count & Remove
1/2" (12.7 mm) Bumps and Dips

Figure #24

MONITOR

Form 821301
4-85

Iowa Department of Transportation

Iowa Transportation Center Materials

7.6 METER CALIFORNIA PROFILOGRAPH

☐ Revised Report
Changes Lab. No. _____

☐ For Information Only ☐ Preliminary ☐ Intermediate ☒ Final

Lab No. 1PR3-06 Route No. I-80 Project No. IM-80-5(164)154-13-50
Date Reported 7-27-93 Date Paved 6-21-93 County Jasper
Tested At: ☒ ¼ Point ☐ Wheel Track Contractor Manatts Inc.
Tested By Trueblood - Brinkman Date 7-26-93
Trace Reduced By Makedonski Date 7-27-93

☒ Primary Schedule A ☒ PCC Slip Form ☐ ACC Paving
☐ Primary Schedule B ☐ PCC Fixed Form ☐ ACC Resurfacing
☐ Secondary ☐ PCC Bonded Overlay ☐ ACC Patches
☐ Municipal ☐ PCC Unbonded Overlay
☐ Other ☐ PCC Patches

Roadway Type: ☐ 2-Lane ☒ 4-Lane ☐ Ramp Other _____

☐ Northbound ☐ Eastbound ← Direction → ☐ Southbound ☐ Westbound
☐ Inside Lane ← (4-Lane Only) → ☐ Outside Lane

Length km (Miles)	Measured Roughness mm (Inches)	Profile Index mm/km (Inches/Miles)	Location (Station)	Length km (Miles)	Measured Roughness mm (Inches)	Profile Index mm/km (Inches/Miles)
			2062+70±	0.161(0.10)	7.62(0.30)	47.3(3.00)
				0.161(0.10)	2.54(0.10)	15.8(1.00)
			2047+73±	0.138(0.086)	1.27(0.05)	9.2(0.58)
				0.460(0.286)	11.43(0.45)	24.8(1.57)

Comparison

Contractor Lab No.	Contractor Results	DOT Results	Difference	IM 216 Tolerance
93-3-1	31.6 mm/km (2.00 in/mi)	24.8 mm/km (1.57 in/mi)	6.8 mm/km (0.43 in/mi)	15.8 mm/km (±1.0 in/mi)

Station ← 12.7mm (½") Bump Locations or 12.7mm (½") Dip Locations → Station

Copies

_____
Iowa Transportation Center Materials Engineer